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A Brief Historical Look at Two Centuries of Climate Change Findings in Public Dialogue

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Abstract: Drawing on scientific and scholarly sources, the article offers a short examination of recurrent themes in the history of public and scientific dialogue concerning climate change science, from the nineteenth century to the past several decades. The article asserts that certain themes have affected quite powerfully the public dialogue about climate change, including the challenges of effective scientific communication and endeavor, reaching and improving on scientific consensus, and taking public action against climate change amid recurring limitations and obstacles.

Keywords: climate change history, climate science history, global warming history, public opinion and climate change

In 1957 when historian A. Hunter Dupree wrote, “In a narrow partisan sense, science has seldom been a political issue,” he could not have envisioned the drama, over environmental issues generally and climate change specifically, that emerged in Congress during the last few decades.¹ Nor would anyone, most likely, have guessed at the changes to be made in the Department of Defense (DOD) in the same time period. But indeed, even the military has had to embrace changes in energy and environmental policy within its ranks. As one of the deputy assistants to the secretary of defense explained, “At the Department of Defense, we deal with risks all the time. That’s what the military does.

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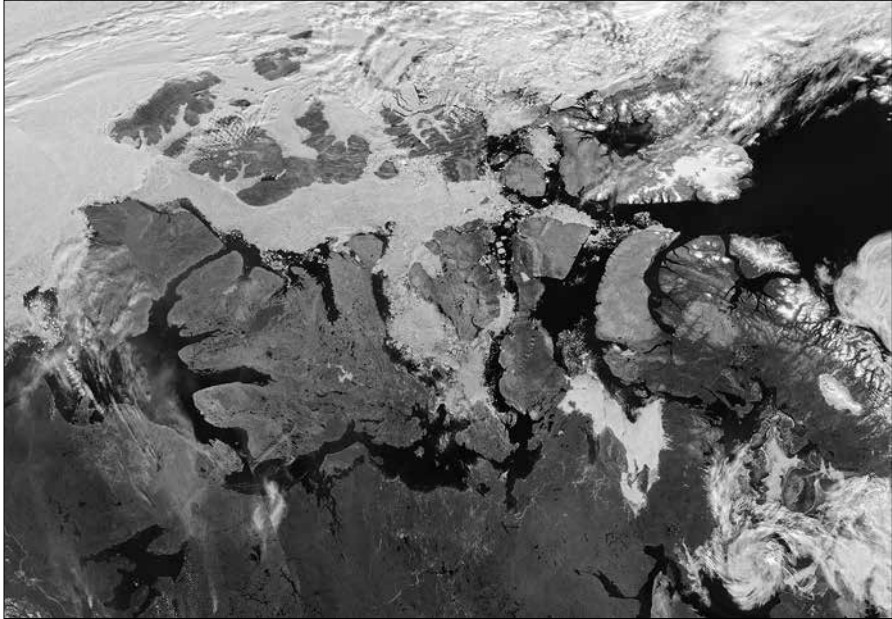
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We evaluate risk and say, ‘Well, given these probable scenarios, how should we plan to address them?’ That is the military mindset.”² Yet Hunter Dupree’s and Maureen Sullivan’s forthright statements bely the larger contentiousness of the issues caused by scientists and advocates pushing the issue of climate change into the public debate long before Presidents Richard M. Nixon or Barack H. Obama made their marks on American environmental policy.

To recount any part of the history of dialogue on the science and risk of climate change is to immediately encounter recurring themes. Since the nineteenth century, scientists around the world have looked into the causes and risks of climate change, but the public results of their inquiries have often been watered down because of various bulwarks created by institutional and technological obstacles, dissent from religious authorities and other nonscientific groups, and lack of consistent data. For those unaware of the historical context of the science behind climate change, these obstacles to moving the scientists’ results into the policy realm might seem like new problems, but are in fact old ones. Consider for a moment just a few of the major investigators and popularizers of climate change, especially what was most popularly known in much of the twentieth century as “global warming”: Svante A. Arrhenius (1859–1927), the Victorian-era, Swedish investigator pondering the levels and effects of CO₂ in the air; Guy Stewart Callendar (1897–1964), a British engineer appearing before a skeptical Royal Meteorological Society almost on the eve of the Blitz to present his pioneering conclusions that Earth had warmed since the late 1800s and that doubling atmospheric CO₂ would make it two degrees Celsius hotter; Charles David Keeling (1928–2005), an American scientist patiently gleaning atmospheric CO₂ data from Mauna Loa and Antarctica year after year during the Cold War; American professor James E. Hansen (1941–) delivering his jeremiad testimony in 1988 on Capitol Hill in the then-hottest summer on record; and former Vice President Al Gore (1948–) telling the necessary, if inconvenient, truth in an unlikely PowerPoint-turned-book-turned-movie hit. These names, which have become icons for the advocates of climate change, faced recurrent obstacles to getting their ideas accepted widely and fully integrated into policy.

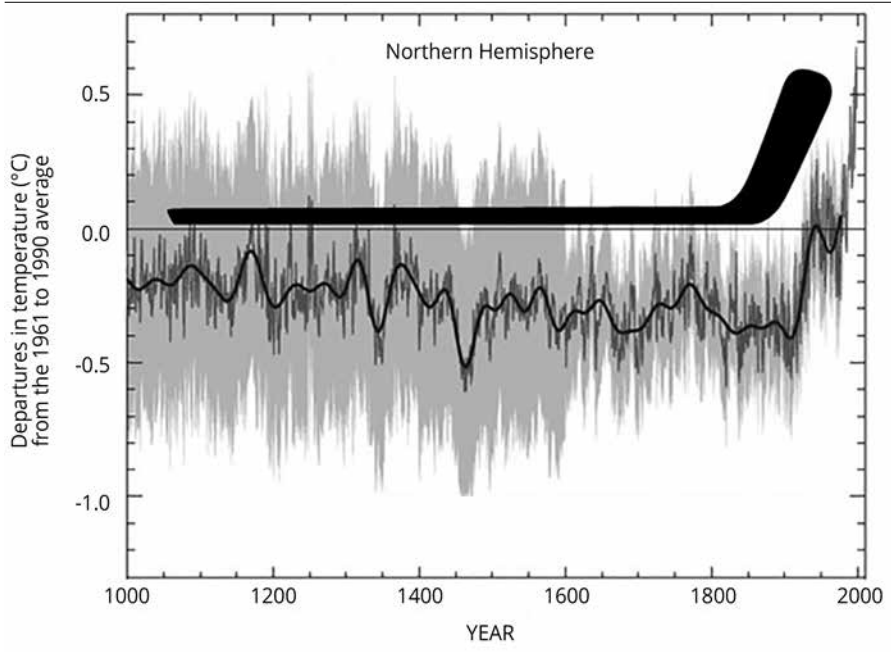
And abounding also are the strangely riveting conceptual and visual icons. Earth’s air as a “greenhouse,” heat “sinks,” melting glaciers, stranded polar bears, and an open Northwest Passage (figure 1). Human icons have created their own visuals as well, including two justifiably famous and crucial curves. The Keeling Curve charted the steady rise of atmospheric CO₂ since 1957, and the Mann-Bradley-Hughes “hockey stick graph” of 1998 displayed global mean temperature increase with the recent business end of the “stick” evidently poised to take a nasty slap-shot at Earth if people do nothing or even too little (figure 2).³

Figure 1. Northwest Passage, 2013



Courtesy of National Aeronautics and Space Administration.

Figure 2. The Mann-Bradley-Hughes “hockey stick graph”



Courtesy of the Intergovernmental Panel on Climate Change, adapted by MCUP.

The icons in the climate change debate and the narrative behind it are certainly multiple and dramatic respectively, but the ironies and limitations under which successive scientific generations have labored in the past may in fact be even more telling because they have shaped present debate in unexpected ways. By placing the debate into a useful context, some insight into those historical ironies and limitations—how they have affected debate and discussion and how they have echoed and reverberated over time—may be helpful to those grappling with this worldwide challenge of the twenty-first century. This includes the basic history of the findings related to climate change and the major responses to them, which should offer an appreciation of certain key historical patterns.

The core objective for this article then is to show how today's climate change debate in the United States remains strongly conditioned by both positive and negative historical factors. These include the positive rise of collaborative team science, the participation of eloquent scientists in the public discourse, and the use of ever-more sophisticated and accurate tools to reach and improve scientific consensus as the strongest basis for policy action. But they also encompass the negative effects of the mid-to-late twentieth-century clamor of multiple environmental and societal crises demanding attention, relegating climate change to a lower priority amid such challenges as control of DDT and industrial pollutants. Additionally, the history of official action on the climate change “finding” as it has played out in scientific and public discourse dramatically reveals a decades-long delay between the basic nineteenth-century and early-twentieth-century discovery of anthropogenic climate change and the late-twentieth-century call to do something about it. We cannot alter the fact of the delay between establishing the scientific knowledge base and its serious consideration by the public and politicians. Yet, it may be helpful to recognize that because of it, and other factors, much of the modern discussion of climate change policy in the United States has been characterized by shifting public opinion that has only recently “caught up” to earlier findings, amid seemingly constant struggles on the part of scientists and concerned policy makers to effectively convey the urgency of the threat.

The article that follows neither tries to be a full primer on the science of climate change nor a comprehensive history of the subject; others have tackled and mastered those more detailed needs.⁴ Rather, it seeks to set the modern U.S. climate change debate (1970s–2010s) in context by first providing a short overview of the key scientific and public developments prior to that, then examining some aspects of the more recent history to elicit insights into how modern debate and dialogue have proceeded under various, continuing limitations. Here, we will try only to shine a brief interpretive spotlight in an effort to

spot significant patterns, echoes, and reverberations as one means of “thinking in time” to aid current policy makers.⁵

One further prefatory note is worth making, which serves to illuminate key terminology and presages a major transition in public and policy climate change-related attitudes since roughly 1970. Over time, scientists and decision makers grappling with the basic findings have used a variety of words and phrases to characterize the basic problems and threats. Victorian-era and early twentieth-century observers might not have known what to make of such phrases *global warming* or *climate change*; experimenters, at the time, instead wrote of the “influence” and “effects” of carbon dioxide “adsorption” or “absorption.” Gradually, scientists after World War II and into the 1970s, studies of CO₂-induced temperature increases began trending toward use of the term *climate* but paired it with variant nouns, such as *modification*. For example, Massachusetts Institute of Technology authors famously enshrined “inadvertent climate modification” in a 1971 technical report.⁶ Global warming, though already in use by 1979 to denote one major climate impact, gained currency as shorthand for the entire problem thanks to popular press attention paid to the congressional hearings of 1989, including NASA Goddard Institute for Space Studies Director James Hansen’s testimony.⁷

Ultimately, however, *climate change* rightly came to be accepted as the term of art for the overall issue and challenge, as scientists and policy makers began reaching a consensus that effects of the warming would include multiple impacts that might not always seem connected to global warming. Initially, *climate change* may have first appeared in a 1975 *Science* article written by Wallace S. Broecker of the Lamont-Doherty Earth Observatory, but it achieved its current and correct usage as referring to the array of possible long-term changes in Earth’s overall or regional climates caused by CO₂ increases more recently.⁸ In this article, we will generally use climate change as the term for the entire spectrum of climate effects, but we will also periodically refer to other terms, including global warming, when they are appropriate in their specific historical periods.

The Climate Change Debate and Discussion

Climate change as a finding of importance did not spring full-blown and ominous from the authors and producers of the movie *An Inconvenient Truth* (2006). It shares with other major scientific discoveries, such as ecological thought or the development of atomic theory, a fascinating two-century history replete with chance discoveries and wrong results, prescient guesses, and spirited and productive disagreements.⁹ Yet what is so extraordinary, especially in light of these complexities, is that the central tenet—that Earth’s atmosphere is warming at an unprecedented rate since the Industrial Revolution began due

to human production of greenhouse gases and such warming is causing many impacts—was effectively reached and largely agreed on by the 1960s within scientific circles, even before the advent of powerful supercomputers that allowed for the making of evermore sophisticated models of the atmosphere. These supercomputers, of course, made possible the “multiple model consensus” approach so critical to the conclusions of the National Academy of Sciences, the Intergovernmental Panel on Climate Change (IPCC), and other key institutional players since 1970. A look at how the central climate change tenet was reached and ramified suggests that scientists, though marked by the cultural, theoretical, and technical limitations of their time periods, nevertheless did a remarkable job of reaching a valuable consensus on the basic finding well before 1970. Yet a range of post-WWII limitations and suspicions, all related to the uneasy and often ironic interactions of science, society, and government since the 1960s—one might even say after Hiroshima and Nagasaki—have seriously affected the climate change debate and the search for a unified national and worldwide approach to solutions.

Nineteenth-Century Icons Lay the Groundwork

While Hollywood, in countless biopics, has romanticized the Pasteurs and Edisons, it is true that the period from the Battle of Waterloo through World War I, which saw the first basic work done on global warming, was a period of science commanded by strong, frequently iconic international figures dominating laboratory resources to go after key empirical data but who were also often hobbled by isolation. Moreover, while laying the groundwork for much of the science that would be built upon their work later, they were limited theoretically and analytically. Important events and trends in the nineteenth century included work done by Joseph Fourier, Louis Agassiz, John Tyndall, and Svante Arrhenius. In 1824, Joseph Fourier, a mathematician, completed calculations that demonstrated that atmosphere influenced world temperature and that Earth would be much cooler in the absence of an atmosphere. Fourier, in realizing that the atmosphere acted to keep in a part of the heat emanated from the Sun, also was first to offer the simple comparison of Earth to a glass-covered greenhouse.¹⁰

Following Fourier, nineteenth-century advances were prompted by true icons in the history of science who helped fill in the gaps of the big climate picture even as they pursued other goals. In the 1830s, Louis Agassiz used his expertise in geology to add to the collective knowledge by postulating that Earth had gone through one or more ice ages, and thus the world was far more dynamic than was considered at the time and was influenced, albeit in the relatively distant past, by large-scale rapid, catastrophic climate change. Though focused on dramatic cooling trends, Agassiz and his followers showed that

Earth's past history was marked by major events that had an impact on climate. Efforts to learn more about ice ages continued to prompt many investigations into global temperature variations.¹¹ By 1859, the physicist John Tyndall asserted that certain gases in the atmosphere acted to stop infrared radiation and that climate could change if gas concentrations increased. Tyndall crucially found that CO₂, in particular, was opaque to infrared radiation and materially contributed to a heightening of Earth temperatures.¹² Near the end of the century, another human icon responsible for basic discoveries in chemistry, Svante Arrhenius, went beyond a possible reason for why Earth grappled with CO₂ concentrations, showing that indeed its climate was more sensitive than previously considered. In a pioneering look at what is now termed *climate sensitivity*, Arrhenius famously demonstrated that either cutting in half, or doubling, CO₂ atmospheric concentrations could mean a 4–5 degrees Celsius change in average Earth air temperatures.¹³

Overcoming Limitations

For all these breakthroughs, however, the limitations suffered by nineteenth-century investigators, such as those named, were indeed severe. First, although scientists communicated with each other personally, via journals, and through such self-appointed governing groups as the Royal Society of London for Improving Natural Knowledge (or simply the Royal Society), the discipline of science as a large, well-funded, and officially backed worldwide endeavor with an available “army of labor” did not yet exist. No wide-ranging, regularly convening conferences or panels met, and investigators thus worked in comparative isolation, pursuing research as far as they could but sustaining few long-term collegial teams or ties across national or educational boundaries. Yet, public faith abounded in practical science and technology, often cast in nationalistic terms, while scientists strove for means to make a larger impact on the knowledge of the world. Second, research efforts to build on and deepen understanding of findings were hobbled by the lack of an army of researchers to systematically collect evidence from around the world, as well as by the lack of sufficiently sophisticated measuring and computing instruments able to crunch such data, assuming it had been available. Arrhenius, for instance, posited largely correct conclusions, but he and his collaborators simply were unable to collect the more comprehensive data that would have been needed to fully explicate the findings on climate sensitivity.

Third, tests and findings were set against a backdrop of titanic, unresolved struggles over larger, first principles about Earth and atmospheric science. Conflicts such as the Darwinian debate over evolution, the geologic dispute over catastrophism and uniformity, and the battle over the age and origins of

the world overshadowed experimental scientific concerns about the atmosphere and any impacts on it from European and American industrialization. While communication and data collection had hobbled scientists in collecting data and testing their hypotheses, other social factors—such as the Catholic Church's insistence that evolution and, indeed, any ideas of planet-wide changes were false—formed a well-funded, respected, and long-lasting opposition to many of the scientists' fundamental premises, most of which became the basis for our present understanding of the world. Religion-based views that processes of the earth and air were essentially unchanged and unchangeable since creation still were prevalent in the eighteenth and nineteenth centuries. This may have provided comfort to people confronted by the dislocations of the Industrial Revolution. Thus, the idea of rapidly occurring global, or even regional, catastrophes in Earth history routinely encountered entrenched enemies. These ideas posited by Agassiz and other Ice Age investigators came under attack, foreshadowing more recent popular suspicion of scientific predictions of the imminence and speed of the potential catastrophe represented by climate change.¹⁴

With all of these issues at hand, scientific inquiry into global warming and climate change, thus, could not move too far forward, let alone influence policy makers for a variety of reasons. As seen from the discussion above, science institutionally was neither unified nor well-funded as a profession, data was scant, and instruments were minimally refined. Moreover, basic matters regarding atmospheric and climate dynamics—rapid changes versus static timelessness, the interactions of air and ocean, feedback loops among simultaneous processes—were just beginning to be addressed. Nonetheless, a kind of loosely defined research program focused on these topics and questions had begun to emerge by the end of the nineteenth century as international scientists continued their research.

Overall, debate and dialogue about climate change science in the nineteenth century took place almost entirely within the realm of individual scientists communicating via personal and professional networks of letter writing and publications. The debate did not spill over into the arena of politics and government, either national or international, because as yet no problem requiring official actions had been identified given that the fundamental concept of geophysical change was still questioned in many quarters. The pattern of creative scientific dialogue within science was set, however, and would flourish as scientific communications and research data and techniques got much better in the twentieth century. Moreover, governmental interest in what the scientists were doing and thinking grew, as expressed by greater funding but also greater controversy.

Making a Public Problem

Science as a professional discipline was utterly transformed in the tumultuous twentieth century, and the old nineteenth-century iconic-style of climate change investigation and discourse was transformed along with it. While discussion of global warming as a major climate impact under the full public spotlight did not occur until well into the 1960s, the basic science needed to have this conversation greatly expanded and deepened before and after WWII, driven by U.S. federal and institutional funding. Although sophisticated modeling of the atmosphere awaited exponential increases in digital computing power, scientists developed a consensus approach to identify atmospheric CO₂ and global mean temperature rise as signs of a crucial problem. The problem, in turn, began to be defined as an important public issue for policy makers and scientists to address. Because many people involved in current debates and decisions may be unaware of the pre-1970 era science related to climate dynamics, it is even more important to consider some of the crucial events and trends in the twentieth century. These events laid the groundwork for understanding the push for broadly based consensus and response to climate change, as well as delineating patterns of delayed recognition of the issue and consequent challenges to that response.

Professionalizing Meteorology

Prior to and during WWII, the professionalization of meteorology—in the interest of better prediction capabilities—prompted enhanced governmental and university data collection concerning climate characteristics and processes.¹⁵ The National Oceanic and Atmospheric Administration's (NOAA) precursor, the National Weather Service and other weather services, began to secure more refined data on a wider range of variables and conditions. Though often focused on localized, or at most regional “weather,” rather than broader climate change, this effort nevertheless provided methods for sorting out climate complexities (e.g., laying to rest such myths as “rain follows the plow”).¹⁶

Reflective of the new involvement in the climate change-related science of meteorology was the work of British scientist Guy Stewart Callendar, whose ideas strongly resonated in the U.S. scientific community after WWII. Essentially an engineer who had taught himself meteorology, Callendar built on extensive meteorological observations from 147 weather stations to conclude in 1938 that global temperatures had risen due to CO₂ creation by human-generated “fuel combustion” by about 0.3 degrees Celsius since 1888. In light of later debates, it is interesting to note that, in 1960, Callendar speculated that his assertion was not too well-received in 1938, in part, because it focused on a single factor rather than a complicated array of forces. Callendar also had presented the then-still shocking assertion that humans could actually influence

something as large as global climate over time. Moreover, before 1938, other meteorological studies had focused instead on water vapor absorption rather than CO₂ atmospheric content. And lastly, Callendar only half-joked that his 1938 scientific audience “did not think of it themselves.”¹⁷

Callendar’s later reflections underscored the reality that his scientific voice, though ultimately the one closest to climate change truth in the early twentieth century, was by no means the only one heard at the time. The greater professionalization of meteorology and other climate-related science did not immediately lead to a consensus on climate change findings, let alone the need to take policy action. Historian James Rodger Fleming has documented well how the availability of more sophisticated technical and experimental methods produced a varied array of sometimes conflicting analyses. Fleming posits that “in the first half of the twentieth century, most scientists did not believe that increased CO₂ levels would result in global warming” and that “other mechanisms of climatic change, although highly speculative, were given more credence, especially changes in solar luminosity, atmospheric transparency, and the Earth’s orbital elements.”¹⁸ Overall, meteorologists provided more concrete data, but not as many advances in producing correspondingly well-accepted interpretations.

Pioneering Publication and Public Discussion

As science became more professionalized and, indeed, more “global” during the first six decades of the twentieth century, multiple scientists began to use official venues and sponsorship to revisit, reassess, and eventually reaffirm the basic Arrhenius-Callendar conclusions regarding anthropogenic CO₂ and its effects on Earth.¹⁹ Historian of science Spencer R. Weart has aptly noted that, beginning in the 1950s, Cold War concerns ironically freed up more military money to investigate CO₂ and temperature rises in the United States, especially in the wake of the Soviet launch of the first artificial satellite. Globally, scientists were supplemented with funding from the International Geophysical Year, a late 1950s initiative toward expanding global science.²⁰ Official funds, thus, backed breakthrough studies by various scientists, such as Gilbert N. Plass who found that adding CO₂ to the air would materially affect the radiation balance, Hans E. Suess who studied how ancient carbon released through fossil fuel combustion was significant, and Roger Revelle who proved that anthropogenic CO₂ was not easily absorbed by the oceans.²¹ Keeling’s patient and persistent measurements of rising atmospheric CO₂ concentrations likewise benefited from a continued, if sometimes unpredictable, influx of federal money.²²

With the availability of fairly regular funding, a core group of scientists focused on climate change began to emerge and contribute to official reports well before 1970; these reports collectively represented the first benchmark

achieved by modern climate science, which got noticed in the United States. Though called by other names, including global warming or greenhouse gas forcing, climate change began to take its place as one among many defined environmental challenges the nation was facing. Though Revelle appeared before the U.S. Congress in the mid-1950s to testify about CO₂-induced climate changes, 1965 marked the key year in many ways. As Weart has noted, Revelle and his Scripps colleagues were at the heart of a National Center for Atmospheric Research conference on causes of climate change in 1965, but that was also the year when the President's Science Advisory Committee subpanel reported that climate change as one of numerous environmental problems was, nonetheless, real and a topic worth of public policy concern, warranting further study by the National Academy of Sciences.²³ The National Academy's inclusion of the climate change problem on their list of issues meriting more study was, in itself, a significant, early acknowledgment of the emerging scientific consensus around the topic; it also served to underscore that interested policy makers should recognize that scientists concerned with the issue were now continually seeking broader consensus, rather than isolated findings, as the best contribution they could make toward any public action. Yet, further investigations in the 1960s and 1970s spelled additional delay in any serious governmental actions or expenditures to halt or retard the effects of climate change.²⁴

Getting the New Science into Policy

Though science, long before 1970, had thrown off the limitations of isolation and sparked official interest in what proved to be the right climate change findings, serious work, nonetheless, ran into significant constraints of its own when it came to spurring and steering public action. Indeed, science and data collection had become more systematic but also more complex, as multiple investigations pointed squarely to the need to collect still more temperature and CO₂ data measured over longer periods of time, as evinced by Keeling's long-term commitment to sampling at Mauna Loa and Antarctica. Increasingly, this was how science best and most successfully proceeded—by repeated and varied experiments and testing hypotheses against a pattern of honest admission of theoretical and data gaps. But policy makers, alerted to the overall problem, needed a clear and loud alarm to mandate major official action backed by citizen support. Hence, they still had difficulty doing much more than entertaining, and sometimes granting, further funding for investigation of the problem.

Understanding the reasons for the disjunction between the scientists and the policy makers, which ultimately delayed any serious policy actions until much more recent history, may be instructive to today's officials who still grapple with converting scientific recommendations into clear and sensible initiatives. Science admittedly was reluctant to say "case closed" to policy makers, let alone

make specific recommendations for change, when, in fact, the state of the field and appropriate scientific protocols both called for more and better research as well as refinement of atmospheric theory and models. The new challenge, rather, was for policy makers to forge ahead on the strength of the basic conclusion that anthropogenic climate change posed a serious threat, even while supporting further research and theoretical discussion. The risk, now a familiar one, in the 1960s and 1970s was that fostering more “science” might well lead to still more questions about how best to define climate sensitivity and the range of likely climate impacts that the very policies were supposed to mitigate.

But a second reality of the pre-1970 era made doing all of this even more difficult if not well-nigh impossible. The global warming problem, even as it began to be cited in official reports of the 1960s, was just one among many environmental and social issues crying for attention, and those other issues appeared far more urgent. Clarion calls about modern, urban postwar problems, such as Rachel Carson’s *Silent Spring* (1962) and Ralph Nader’s *Unsafe at Any Speed* (1965), were heard and acted on precisely because such problems as water pollution, pesticide poisoning, and automotive defects were readily grasped as having actually killed animals and people at the time. These problems had what were seen as relatively simple solutions compared to the potential complexities of responding to the longer-term problem of climate change (i.e., clean up the industrial sludge or oil spills, restrict or ban pesticides, and get rid of factory defects in cars). Issues such as these were hardly free from political pressure; many manufacturers, at first, lined up against new regulations, a pattern to be seen later in the climate change debate. It was hard for anyone to mobilize in favor of action on climate matters when science itself wanted more data and more refined atmospheric theory while pressing problems were easier to understand and try to solve.

Perhaps scientists could have done a better job of forthrightly explaining to the public and governments that anthropogenic climate forcing was a more urgent (if more complex) matter requiring action. Based on the evidence, it is hard to say so, largely due to more intractable problems. During the world war, the nation mobilized with the help of the government, creating a military-industrial complex that won the war on two fronts. Yet the bureaucracy that brought the nation to victory did not look as good to Americans after the war. Growing public suspicion after World War II, on the Left and Right, of government and the scientific “establishment” began to intrude on this interaction and become widespread by the end of the 1960s.

Though scientists were traditionally independent and did not have a single “spokesperson” or group, science along with government even in the 1950s was already blamed in many quarters as having brought the mixed blessings of the atomic age. If “atoms for peace” brought benefits of atomic energy that could

be part of the legacy of Los Alamos, New Mexico, so too were fallout and the fear of mutually assured destruction in a third world war. NASA achieved John F. Kennedy's dream of moon exploration, but the Manhattan Project-scale investment in the Apollo program occasioned questions about whether funds should ever again be spent at such a level for any purely scientific challenge. Then the puzzling military loss in Vietnam, despite large expenditures of lives and money, coupled with the later revelations of widespread official misdeeds in the Watergate era, led to a "credibility gap" where the public no longer maintained a general faith that everything the government said or recommended was right, particularly if it required a major taxpayer commitment.²⁵

Though policy action on global warming was delayed and wanting for these reasons, twentieth-century climate science up to the early 1970s had, on balance, achieved two accomplishments significant for the era and the future. First, scientists had given a comprehensive grounding to the more sporadic earlier findings and had begun to agree that the research agenda had essentially moved beyond simple assertion of the reality of global warming to a full consideration of what specific climate impacts could be anticipated and when and how, as a potential basis for a constructive and meaningful policy response. Policy reports began to cite climate change as an issue demanding some attention, albeit among many environmental problems clamoring for funds. And second, through official funding, in part, that spurred more comprehensive data collection and theoretical study, the core group of experts around Revelle and his colleagues and collaborators had established the building and communication of scientific consensus over workable models as critical in providing a credible springboard for any policy actions. The latter accomplishment, easily as much as the former, would come to characterize climate change scientific and policy-making work since circa 1970, including the public debate and dialogue we see today.

Reaching for Consensus after 1970

If a basis for understanding climate's effect on people was laid between 1824 and 1970 for scientists trying to reach agreement as a means of communicating findings and spurring policy, seeking consensus around climate change in the nation and the world since 1970 has become a praiseworthy and necessary, if not critical, goal. Scientific collaboration and consensus building about climate change is praiseworthy because that is how science and policy should best proceed; it is necessary and indeed crucial because the urgency and global reach of the problem means that national and international action cannot be delayed, even though data gaps and perhaps theoretical disputes persist. Broad and deep consensus, in fact, has come to be the most powerful policy tool contributed by science to policy making since the 1970s. Highly reflective of this has been

the now-regular, periodic discussion of findings and research gaps, through the vehicle of U.S. groups, such as the National Academy of Sciences, and bodies in which the United States are instrumental, notably the IPCC, the key international policy-setting forum formed under United Nations (UN) auspices in 1988. Rather than offering isolated though striking results, as Arrhenius, Callendar, and in the early years of the investigations Revelle did, scientists increasingly since 1970 used more formal groups to funnel their information for more effective consumption by policy makers and the public.

Ultimately, the scientific community and its supporters pushed its concerns to the forefront, despite renewed political questioning about whether the basic findings on anthropogenic warming were valid. This left, however, the field open for the still-vibrant dialogue as to questions of “climate sensitivity” (i.e., what climate effects would occur and when they would likely happen). Yet the dramatically greater public spotlight shone on climate change since 1970 also injected all manner of public debate and dialogue into the often fickle and shallow daily news cycle. At the same time, an array of fears arose and were stoked as questions materially affecting policy decisions and potentially large public expenditures emerged. Many of these fears were reverberations of older, entrenched popular suspicions, including beliefs that science and government, having brought decidedly mixed blessings on other social and technological fronts, could not be trusted. Policy questions were bedeviled by the difficulty of recognizing and allocating sizable funds to combat an environmental problem that was as yet only one of many and that public opinion, so critical to public action, was still struggling to apprehend. Though the danger of studying such contemporary history is that the historian is still a witness to its continued unfolding, a review of the key trends seen since about 1970 in the climate change dialogue provides crucial context to understand what is in today’s—and the future’s—news and how the facets of the current climate change dialogue evolved and became established in our recent past.

Computers, Risk Analysis, and Data Collection

If old fears were stirred and public views in the United States about climate change varied, science immeasurably aided policy makers by grounding the new consensus building in broadly collected data and corroborative analyses, rather than isolated observations and theories. Echoing the early-twentieth-century professionalizing of meteorological instrumentation, the advent of exponentially better computing capabilities after 1970 profoundly affected climate change science, allowing for evermore sophisticated atmospheric and earth sciences modeling. The dramatic increase in computing power, perhaps the greatest boon of the modern era, has permitted better scientific simulation of complex interactions. This includes feedback processes, involving such

phenomena as clouds, storms, albedo, and reflective characteristics of terrain and sea; El Niño and La Niña events; the thermohaline circulation of ocean currents; paleoclimatology, as a distant yet direct successor of Agassiz's Ice Age findings; and ice melting. While models and modeling were continually improved, reaching a "critical mass" of multiple models in agreement became a prerequisite of meaningful policy actions. Models being created by the late 1990s began to permit playing out of various risk-level scenarios as well. Scientists were for the first time able to ask and also reliably answer questions about how soon climate warming will reach a "tipping point" or how much sea level increase will come from various calculated potential temperature rises.

With the rise of sophisticated computing and especially the tremendous expansion of the Internet, beginning with its pre-1980 federally sponsored scientific precursors, such as DARPA Net, data collection on climate change around the world expanded and truly engaged for the first time an army of labor. Even as computers and computing got better, instrumentation and techniques available to investigators underwent major change and improvement. Setting climate trends in a valuable paleoclimate context, by measuring previous changes using ice cores, was one powerful example of such increased capabilities. The responsibility of governments to cooperate with, and hopefully foster, scientific data collection also expanded to all parts of the world. Nations signed on beginning in the late 1980s to the UN framework that prompted creation of the IPCC, after what might well be considered a kind of "pilot" project combating a different yet analogous threat. Under the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, UN participating nations were able to come together to restrict chlorofluorocarbons (CFCs) and their impact on the ozone layer.²⁶ From the 1980s on, national governments, including the United States, began to recognize the value of the new, more comprehensive data and strove to come to consensus, much like the scientific community, regarding appropriate global environmental policies.

Climate Change Studies, Programs, and Reports

With climate change emerging as a key issue by the 1970s, the door opened for more systematic and sustained climate change programs and studies to be done, issuing influential reports on the national and, eventually, the international fronts. In the United States, these programs were first spearheaded by the 1970s studies sponsored by the National Research Council and National Academy of Sciences. Climate change study programs also benefited from greater funding for federal agencies, such as the EPA, NASA, NOAA, and DOD, all of which gradually posited climate change as a national risk (though still one among many in the 1970s and 1980s) that needed to be better understood so as to properly develop policy responses.²⁷ Publication levels of federal studies re-

flected this pattern; a search of the EPA's online database, the National Service Center for Environmental Publications, reveals 5,878 hits on "greenhouse gas" and 2,900 hits on "global warming;" the earliest such hits were for EPA studies dating from 1974 and 1980, respectively.²⁸

But the issue clearly now was entering public policy discourse, with calls for more research, yet also striking an increasingly urgent tone. Many histories note the 1977 National Academy of Sciences's report indicating that neither panic nor complacency should be the reaction to the basic findings; the 1979 National Academy of Sciences's conclusion that doubling CO₂ concentration would occasion a 1.5–4.5 degree warming; and the 1983 EPA report whose very title, *Can We Delay a Greenhouse Warming?*, all revealed the shift toward a serious policy response. Similarly, a key 1980 report, prepared by Mitre Corporation for EPA's Office of Strategic Assessment and Special Studies, included strong language presaging more recent warnings incorporating risk analysis and climate sensitivity. The authors did not mince words with the following statement, "Increased concentrations of CO₂ in the atmosphere could profoundly and irreversibly alter global climate. Regional climate shifts could reduce the capacity of major world supply food regions to feed mankind, leading to disruption of international food markets, food shortages, or rationing." The Mitre team then hit upon topics that have been the subject of concern for a number of government agencies, including the DOD: "Other possible effects include changes in regional hydrology and rising sea levels due to polar ice melt. Coastal development, recreation, agriculture, water intensive energy, and industrial facilities, and resident populations could be affected on an almost unimaginable scale."²⁹

Set against this rising tide of ever-more urgently worded reports, NASA's Goddard Institute for Space Studies Director James Hansen's landmark congressional testimony of 1988 represented the first culmination and realization of a trend that had begun much earlier. Hansen, as is well-known, dramatically brought home to Congress the emerging scientific consensus that human activities were "forcing" CO₂-induced climate change; such forcing had to be hindered or stopped or else humanity would face potentially irreversible impacts. Given that so many warning bells were going off in so many quarters in the decade before Hansen's congressional appearance, it is perhaps a bit ironic that his forthright restatement of an already strong scientific consensus became the storm vortex it did in the media. Yet what set Hansen's testimony apart was his unequivocal assertion that potentially irreversible warming was already underway, as the nation reeled from droughts and the hottest summer on record. Others in the 1980s, such as former EPA Administrator Russell E. Train, had publicly underlined the challenge and danger posed by global warming but had indicated that the rates of warming were still unclear.³⁰

Americans Were Listening

Picked up by the *New York Times* and worldwide media outlets, Hansen's testimony—"that the greenhouse effect has been detected and it is changing our climate now"—was indeed galvanizing enough to provide a lightning rod against which numerous others in the growing debate could react.³¹ With the old limitations of scientific isolation and predigital-era uncertainties largely gone, the thrusting of the global warming issue forcefully and dramatically into the public eye led for the first time to significant debate and discussion beyond just the scientific community. Such conflict centered on an array of questions that played out, often superficially and regrettably, in the charged, deliberately "contested zones" of the media and official hearings. Public polling in the immediate wake of the testimony documented an extraordinary uptick of concern among U.S. citizenry; as noted by historian Spencer Weart, in September 1988, some 58 percent of Americans recalled having heard or read about the greenhouse effect, a major rise from just 38 percent in 1981. Most perceived global warming as a threat and believed they would live to experience the impacts of anthropogenic climate change. Other polls documented that more than 80 percent surveyed worried about global warming.³²

Yet longer-term surveys charting public opinion about climate change in the first two decades after 1988 revealed some troublesome fluctuations and uncertainties in popular views, which affected, and were in turn affected by, both scientific and public policy events occurring in the longer wake of the 1988 Hansen testimony. Specific awareness of climate change as a problem remained quite high, rising through the 80–90 percentile range from 1998 to 2006. By 2007, however, only 22 percent believed that they understood the problem very well. Belief in the reality of the global warming threat likewise rose from 68 percent in 1992 up to 84 percent in a 2007 survey, but confidence that scientists had indeed reached a consensus increased from 28 percent in 1994 to only 65 percent by 2006. Despite the Hansen testimony, only about one-third of Americans in 1989–91 worried "a great deal" about global warming as opposed to other environmental issues; between 1997 and 2007, this number rose to just 41 percent, with most reporting that they saw much more of a threat in water pollution and drinking water impurities. In the late 1980s, a large majority preferred "immediate action" against climate change even if costs were high, but by 1998, only 39 percent believed the need was serious enough to incur significant public costs. Significantly, in light of the scientific consensus regarding the urgency of the climate change threat, in both 1997 and the period of 2001–5, only a "bare majority" thought that any impacts had already begun; this rose to 60 percent in 2007, possibly in the wake of *An Inconvenient Truth* in 2006 and related media coverage, but still only about one-

third of the public felt that they would experience any adverse effects within their lifetimes.

If popular grasp of the details of U.S. involvement in international climate change talks and treaties typically scored low, public support for participation in worldwide emission control and reduction was steady. Immediately after President George W. Bush's 2001 controversial decision not to support the 1997 Kyoto Protocol mandating emission reductions in industrialized nations, surveys found that nearly 20 percent more respondents disapproved of U.S. inaction than approved. Support for particular domestic governmental policies also remained remarkably robust and consistent. Opinion surveys from the 1990s to 2007 showed strong support for emission limits on industry and automobiles, production of hybrid vehicles, and tax incentives to encourage energy efficiency and alternative energies, such as solar and wind. There was more division over increasing nuclear energy as well as considerable opposition to increased gas or electricity taxes aiming to influence consumer behavior.³³

These variations in the polls pose a further and seemingly ever-present challenge to national policy makers seeking a political or civic mandates, to build on the broad scientific consensus, as the basis for action on climate change. The gaps and uncertainties in popular views may reflect the impact, during the past three decades, of specific events as well as echoes of past limitations. The pattern of "awareness without knowledge" of what climate change is and entails seems to dovetail with the drop in support for immediate, potentially costly action and the related belief that impacts will not be felt within the lives of those polled. Historically, these results suggest a continued impact of the decades-long official delay on the part of government in recognizing the climate change threat and according it the highest priority. Yet, also evident in these poll results is the effect of active opposition to climate change responses—or even renewed denial of the basic findings—rooted in part in continuing suspicion of big science along with big government solutions. Pinpointing another lingering reverberation from the Watergate and Vietnam eras, Meg Jacobs in her recently published *Panic at the Pump* aptly noted that "the rise of antigovernment sentiment has compounded Washington's inability to deal with twenty-first century energy challenges" and that "this hostility to government resulted in part from the unsuccessful efforts to solve the energy crisis of the 1970s."³⁴

Thus, a question that persisted in some public debate, inevitably if amazingly, has continued to circulate: is climate change caused by human activities real? Yet because doing something about climate impacts required policy decisions affecting a critical economic sector—namely, the fossil fuel industries, just coming off the tumult of OPEC and the gasoline shortages of the 1970s—coal and oil representatives in particular reacted, in part, with an orchestration

of doubt. Just how urgent and global was this supposed challenge; what could effectively be done about it; who should do it; what was it going to cost; and who will feel the impact? Joshua P. Howe, in his study *Behind the Curve: Science and the Politics of Global Warming*, delineated the early 1990s arguments offered by these industries and their political allies, who joined in a “Global Climate Coalition” lobby under the pressure of Hansen’s testimony. Many of the critics’ points first expounded more than two decades ago remain characteristic of current opposition to strong action to combat climate change. Howe found that opponents asserted that the science was not yet fully “in” and verified; that climate change might be not as much of a problem if temperature rises were small; that “climate variation might result from natural, not anthropogenic, processes”; that global climate might somehow be “self-correcting”; and that it would be “an economically disastrous crash course” to mandate reduced carbon emissions if the science was uncertain.³⁵

As climate change scientists finally reached a consensus and forced the issue into the serious policy and public funding spheres, deniers and skeptics also gathered steam to bring doubt to the conclusions of the proponents of mitigation. While outright denial of anthropogenic global warming and climate impacts unquestionably affected the nature and pace of official U.S. actions, the questioning raised in the 1990s and since has also ironically had the effect of making both stakeholders in science and policy “up their game” (i.e., ensure that decisions concerning climate change affecting government commitments and funding are grounded as solidly as possible in defensible, reproducible, and widely endorsed findings).

Stewardship Takes (Re)New(ed) Forms

Perhaps spurred by such strident opposition amid clear public concern and a rising scientific consensus, the 1990s and 2000s also witnessed a significant counterpoint: an outpouring of new (and interestingly renewed) kinds of public stewardship in the face of climate impacts. By 2000, under shareholder and consumer demands, as well as the press of IPCC findings, the industrial Global Climate Coalition had disbanded, as many U.S. industries doing domestic and international business began to realize that reducing emissions was broadly popular among their American customers along with foreign host countries. Hansen and his scientific colleagues continued to publish and testify at hearings, but also benefited from vocal partners and proponents in the policy sphere, such as Al Gore, who had presaged his 2006 *Inconvenient Truth* book and film with an equally strong plea in his 1993 *Earth in the Balance*.³⁶ Keying on Earth Day (established in 1970), the decade of the 1970s had seen popular stewardship that included a number of related smaller movements. For example, with the “small is beautiful” trend toward organic farming and living simply, believing that act-

ing to achieve local environmental gains was thinking globally. The challenge posed by climate change gave new life to this approach, as “carbon footprints” were assessed and “sustainability” criteria were applied to every human activity. Typical of the new, highly popular “act locally” guidebooks was David de Rothschild’s 2007 *The Live Earth Global Warming Survival Handbook*. The book was published as the “official companion to the Live Earth Concerts,” themselves a new forum for climate action, and featured “77 essential skills to stop climate change—or live through it.” De Rothschild firmly, but entertainingly, offered ways to reduce CO₂ emission that included “get hitched,” “say no to Styrofoam,” and “ride the train,” while concluding only half tongue-in-cheek with “colonize space,” “pack a time capsule,” and “evolve.”³⁷

The Past Informs the Present

Certainly, Hansen and others in the late twentieth and early twenty-first centuries have proceeded without interruption to act as Roger Revelle had done in an earlier time: warmly arguing yet working together to reach consensus on findings and related actions, while defining further research agendas to fill data gaps through creative experimentation and to push the science of climate change forward.³⁸ Meanwhile, amid the emerging public consensus that the problem was real and, at least, somewhat urgent, U.S. and international official actions began in the wake of the crucial 1970s and 1980s affirmation of the basic findings and challenges. While sustainability in a thousand ways captured public imagination and fervor, another new but enduring official stewardship response to climate change represented an illustrative instance of its increasingly routine incorporation into high-level policy. Perhaps ironically prompted by 11 September 2001 and the potential threat to national security climate impacts implied, the DOD under President George W. Bush in 2003–4 commissioned two futurists, Peter Schwartz and Doug Randall, to prepare a report on “an abrupt climate change scenario and its implications for United States national security.” Schwartz and Randall urged defense policy makers to “imagine the unthinkable” regarding “significant global warming” to “better understand the potential implications on national security.” Assessing possible regional impacts, such as droughts and famines, they spun out possible “conflict scenarios” that included stresses and risks from migrations and border wars linked to changing amounts of resources. Among their conclusions were that predictive models and metrics needed improvement, and that “adaptive responses” to events driven by climate change should be “rehearsed” by government and military planners much as they rehearsed, gamed, and drilled for other contingencies.³⁹

Though U.S. legal developments such as the 1990 Global Change Research Act may have represented only a start in combating climate change, more

recent federal actions have included a more regular and systematic reexamination and review of U.S. funding priorities for climate change research, a process begun in 2009, as well as the early 2016 issuance of a DOD directive mandating that “the DoD must be able to adapt current and future operations to address the impacts of climate change in order to maintain an effective and efficient U.S. military.”⁴⁰ This important directive hearkened back to the Schwartz-Randall report of 2003–4 but also to a long tradition of military preparedness planning, which historically had included forecasting for meteorological impacts, such as floods and storms.

Last, but emphatically not least, a significant historic triumph for science has also been a policy-making recognition that the consensus-by-multiple-atmospheric-models approach is valid as a means of determining the validity of new findings and of appropriate mitigation and adaptation strategies and policies, including how best to assess the rates and impacts of climate change. The international actions, with the United States once more deeply committed to participating, especially reflect this; flowing from the pioneering Montreal Protocol to restrict CFCs, the successive post-1990 IPCC meetings and reports down to the pathbreaking UN Climate Change Conference (COP21) in Paris through December 2015 have moved too fast for some and too slow for others, but have consistently adhered to this approach in confirming and presenting scientific conclusions as springboards for policy.⁴¹ Even die-hard critics in the U.S. Congress—those engaged in questioning data and sometimes the methods and credibility of those presenting—have perforce subscribed to the power and meaningfulness of the consensus-building approach, forward-thinking but with deep roots in the iconic days of Callendar and Revelle.⁴²

Notes

The views expressed here are the author's and do not represent the views of History Associates Inc. or its clients.

1. A. Hunter Dupree, *Science in the Federal Government: A History of Policies and Activities to 1940* (Cambridge, MA: The Belknap Press of Harvard University Press, 1957), 379.
2. Francesco Femia et al., “Dangerous Intersection: Climate Change and National Security,” *Environmental Forum* 33, no. 1 (January/February 2016): 49.
3. Marc Lallanilla, “What Is the Keeling Curve?” Live Science, 2 May 2013, <http://www.livescience.com/29271-what-is-the-keeling-curve-carbon-dioxide.html>; and Chris Mooney, “The Hockey Stick: The Most Controversial Chart in Science, Explained,” *The Atlantic*, 10 May 2013, <http://www.theatlantic.com/technology/archive/2013/05/the-hockey-stick-the-most-controversial-chart-in-science-explained/275753/>.
4. For excellent detailed summaries, see especially the work of Spencer R. Weart at the American Institute of Physics (AIP). Weart's pathbreaking historical summaries are found in his book, *The Discovery of Global Warming* (Cambridge, MA: Harvard University Press, 2008), and in his continuing topical histories and timelines posted at <https://www.aip.org/history/climate/>; James Rodger Fleming, *Historical Perspectives on Climate Change* (New York: Oxford University Press, 1998), offers valuable insight into the

- pre-1970 period. Other detailed histories include Anthony N. Penna, *The Human Footprint: A Global Environmental History* (Chichester, UK: John Wiley & Sons, 2014). There are also several very good, shorter overviews of the issue and the history of climate change; see, especially, Mark Maslin, *Global Warming: A Very Short Introduction* (New York: Oxford University Press, 2009); David Archer, *The Long Thaw: How Humans Are Changing the Next 100,000 Years of Earth's Climate* (Princeton, NJ: Princeton University Press, 2009); and Bill McKibben, ed., *The Global Warming Reader: A Century of Writing about Climate Change* (New York: Penguin Books, 2012).
5. See Richard E. Neustadt and Ernest R. May, *Thinking in Time: The Uses of History for Decision Makers* (New York: Simon & Schuster, 1986).
 6. Study of Man's Impact on Climate at Massachusetts Institute of Technology (MIT), ed., *Inadvertent Climate Modification: Report of the Study of Man's Impact on Climate* (Cambridge, MA: MIT Press, 1971).
 7. A short, helpful summary regarding terminology is provided by the National Aeronautical and Space Administration (NASA) in "What's in a Name? Global Warming vs. Climate Change," <https://pmm.pps.eosdis.nasa.gov/education/articles/whats-name-global-warming-vs-climate-change>. See also Leo Hickman, "Is It Time to Retire the Term 'Global Warming?'," *Environment* (blog), *Guardian*, 5 August 2010, <http://www.theguardian.com/environment/blog/2010/aug/05/global-warming-birthday-new-name>.
 8. Wallace S. Broecker, "Climatic Change: Are We on the Brink of a Pronounced Global Warming?," *Science* 189, no. 4201 (8 August 1975): 460–63, doi:10.1126/science.189.4201.460.
 9. *An Inconvenient Truth* did unquestionably have a great impact on publicizing the discovery and urgency of long-held findings. See the "script" as issued in Al Gore, *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do about It* (New York: Rodale Books, 2006).
 10. For a short discussion of Fourier as a pioneer, see Weart, *The Discovery of Global Warming*, 2–3.
 11. For an entertaining and instructive history of the work of Agassiz and his colleagues, see Edmund Blair Bolles, *The Ice Finders: How a Poet, a Professor, and a Politician Discovered the Ice Age* (Washington, DC: Counterpoint, 1999).
 12. A concise summary of Tyndall's contributions is in Mike Hulme, *Why We Disagree about Climate Change: Understanding Controversy, Inaction and Opportunity* (New York: Cambridge University Press, 2009), 43–45.
 13. The crucial Arrhenius paper is "On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground," *Philosophical Magazine and Journal of Science*, series 5, vol. 41, no. 251 (April 1896): 237–76, which was based on work he did in 1895.
 14. The First Vatican Council of 1869–70, led by Pope Pius IX, actively opposed any teaching of evolution. This was not modified until the second half of the twentieth century and no papal encyclical dealt with climate change prior to the recent *Laudato si'* (On Care for Our Common Home) issued by Pope Francis, who took up the issue of climate change in 2015.
 15. Better weather forecasting received a great boost from post-mortems after the path of New England's catastrophic 1938 "Long Island Express" hurricane, which was not sufficiently predicted. A second tremendous driver was the military need for accurate measurements of weather and climate variables in WWII and in the subsequent Cold War.
 16. During the late nineteenth century, boosters in arid states such as Kansas argued that the furrows that farmers made during plowing released moisture into the atmosphere that would then be returned to Earth as rain. This was a pseudoscientific claim used to sell land and attract settlers, coinciding with a moment when states west of the 100th parallel happened to have a period of greater than normal rainfall. In addition to the professionalization of meteorology and agricultural science, the Dust Bowl of the 1930s played a major, if unwelcome, role in laying the myth to rest.

17. Hulme, *Why We Disagree about Climate Change*, 53; G. S. Callendar, "The Artificial Production of Carbon Dioxide and Its Influence on Temperature," *Quarterly Journal of the Royal Meteorological Society* 64, no. 275 (1938): 233–40, doi:10.1002/qj.49706427503.
18. Fleming, *Historical Perspectives on Climate Change*, 107.
19. Callendar continued his CO₂ studies and advocacy for more than two decades, although his projected treatise on the subject never became a reality; see James Rodger Fleming, *The Callendar Effect: The Life and Work of Guy Stewart Callendar (1898–1964), the Scientist Who Established the Carbon Dioxide Theory of Climate Change* (Boston: American Meteorological Society, 2007), 65–87.
20. In addition to the military, the Atomic Energy Commission and National Science Foundation ultimately provided research funds that were applied to the investigation of global warming issues.
21. Weart, *The Discovery of Global Warming*, 22–37.
22. For one of the key papers reporting the data gathered by the Keeling team, see Charles D. Keeling et al., "Atmospheric Carbon Dioxide Variations at Mauna Loa Observatory, Hawaii," *Tellus* 28, no. 6 (December 1976): 538–51, doi:10.1111/j.2153-3490.1976.tb00701.x.
23. See Weart, *The Discovery of Global Warming*, 22–37; and Weart's more in-depth study of Revelle's work at <https://www.aip.org/history/climate/Revelle.htm>.
24. Weart in the above-noted works, especially, has underscored the ironic and unfortunate effect of repeat recommendations for "further study" of the threat of climate change without taking any positive actions.
25. The rising distrust of big government and big science in the wake of traumatic national events, such as the Vietnam War, the failure of the War on Poverty, and Watergate, is ably covered in a single text in William H. Chafe's *The Unfinished Journey: America Since World War II*, 7th ed. (Oxford: Oxford University Press, 2010).
26. An excellent short guide to the "ozone hole" effort, as well as to the IPCC and many other facets of climate change issue history, is Robert Henson, *The Thinking Person's Guide to Climate Change* (Boston: American Meteorological Society, 2014).
27. These included the international Global Atmospheric Research Program set up in 1967.
28. The National Service Center for Environmental Publications is available at <http://www.epa.gov/nscep>. Figures current as of search performed on 26 September 2016.
29. Marcia L. Wilson, Laura R. Jones, and Carol J. Kuhlman, *Future Environmental Problems: An Overview of Underlying Trends* (McLean, VA: Mitre Corporation, 1980), 23.
30. See Russell E. Train, "A Perspective on World Environmental Problems," *EPA Journal* 11, no. 1 (January/February 1985): 2–3.
31. See Philip Shabecoff, "Global Warming Has Begun, Expert Tells Senate," *New York Times*, 24 June 1988, <http://www.nytimes.com/1988/06/24/us/global-warming-has-begun-expert-tells-senate.html>.
32. See "The Public and Climate Change," *Discovery of Global Warming*, February 2014, <https://www.aip.org/history/climate/public.htm>.
33. The public opinion findings from the 1980s to 2007 are summarized in Matthew C. Nisbet and Teresa Myers, "The Polls—Trends: Twenty Years of Public Opinion about Global Warming," *Public Opinion Quarterly* 71, no. 3 (Fall 2007): 444–70, doi:10.1093/poq/nfm031.
34. See Meg Jacobs, *Panic at the Pump: The Energy Crisis and the Transformation of American Politics in the 1970s* (New York: Hill & Wang, 2016), 312.
35. Joshua P. Howe, *Behind the Curve: Science and the Politics of Global Warming* (Seattle: University of Washington Press, 2014), 187–88.
36. Al Gore, *Earth in the Balance: Ecology and the Human Spirit* (New York: Plume, 1993).
37. David de Rothschild, *The Live Earth Global Warming Survival Handbook: 77 Essential Skills to Stop Climate Change—Or Live Through It* (New York: Live Earth, 2007), 35, 44–45, 126–27, 148–53.
38. The "hockey stick" curve, presented by Mann, Bradley, and Hughes in their benchmark 1998 article, represented a significant example of climate change science moving

- ahead with valuable work in the mid-1990s. See Michael E. Mann, Raymond S. Bradley, and Malcom K. Hughes, "Global-scale Temperature Patterns and Climate Forcing over the Past Six Centuries," *Nature* 392 (23 April 1998): 779–87, doi:10.1038/33859.
39. Peter Schwartz and Doug Randall, "An Abrupt Climate Change Scenario and Its Implications for United States National Security," reprinted in McKibben, ed., *The Global Warming Reader*, 318–49.
 40. The 1990 act set up the U.S. Global Change Research Program, which still provides the basic general framework for much U.S. action and issues an annual report, *Our Changing Planet*, summarizing latest developments. The Global Change Research Act of 1990, Pub. L. No. 101-606 (1990). DOD Directive 4715.21, Climate Change Adaptation and Resilience (14 January 2016).
 41. The Paris Agreement of December 2015, due to enter into force in 2020, as the European Commission stated, involved a binding pledge made by 195 countries to "a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C." See "Paris Agreement," European Commission, Climate Action, http://ec.europa.eu/clima/policies/international/negotiations/paris/index_en.htm; the IPCC website also includes a handy timeline of IPCC history. In recent years, IPCC has issued concise summaries for policy makers in addition to its traditionally voluminous and detailed assessment and panel reports. See IPCC, www.ipcc.ch.
 42. See for instance, the 23 June 2005 letter of Representative Joe L. Barton to scientist Michael Mann, cited in David Ignatius, "A Bid to Chill Thinking," *Washington Post*, 22 July 2005, http://www.washingtonpost.com/wp-dyn/content/article/2005/07/21/AR2005072102186.html?utm_term=.69a1282eb98e.